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ABSTRACT

Described are about two dozen laboratory experiments, demonstrations and class discussions intended to supplement secondary school biology curricula with energy-related learning activities. Concepts examined in these materials include photosynthesis, energy from biomass, feeding relationships, pyrolysis, and respiration. Lessons contain notes to the teacher, objectives, discussion questions, and recommended procedures. (WB)

ENERGY

PENNSYLVANIA'S ENERGY CURRICULUM FOR THE SECONDARY GRADES

Biological Science

Pennsylvania Department of Education 1980
Funds Provided by Governor's Energy Council

Commonwealth of Pennsylvania
Dick Thornburgh, *Governor*

Department of Education
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INTRODUCTION

A study of biological processes is basic to any comprehensive understanding of energy. All life depends either directly or indirectly upon the photosynthetic process, the vital link between the inorganic and the organic worlds. All living organisms must constantly consume energy to maintain their homeostatic processes, and this energy must come from the sun via green plants. The fossil fuels upon which our national survival depends had their origins in once living organisms.

The activities in this manual do not constitute any type of curriculum. They are designed to augment existing biology curricula, giving students some understanding of the importance of energy in the living world. They require only homemade or easily obtainable equipment. Feel free to use these materials as they are, or modify them to suit your needs. If you have a biology-related energy activity which you want to share, please send it on to the Pennsylvania Department of Education for possible inclusion in a reprint of this booklet. You will, or course, be given full credit for this material.

Activity: Effect of Light Upon Plant Growth

Objective:

The student will investigate the effect of light upon plant growth.

What to do:

1. Obtain four green plants as nearly identical as possible. Coleus or geraniums are excellent choices. The plants should be planted in identical soils and in the same size pots.

2. Place two plants on a sunny window sill, and two plants in a dark closet. Water them with the same amount of water each day.

3. Make measurements of plant height and width every two days. Make notes concerning the general condition of the plants.

4. Related Questions

   4.1 Describe any differences in the plants. What were they?

   4.2 What would happen to the plants if kept in darkness continually? Why?

   4.3 Was light the only variable in this investigation?

Activity: Green Plants and Sunlight

Objective:

The student will demonstrate that a green plant needs sunlight to produce food.

What to do:

Materials needed: A geranium plant, black paper, paper clips, alcohol, pyrex container, hot plate, iodine solution.

Cover two leaves of a geranium plant with black paper and paper clips – one should be partially covered and one completely covered. Leave a third leaf completely exposed. Put the plant in a sunny window for three days. Remove the paper and put each leaf in a separate hot alcohol bath and shake for 20 minutes. (Do not use an open flame around alcohol. Use a hot plate and **be careful!**) Remove and test each leaf with a few drops of iodine solution. Observe the color changes in each leaf. Where did the color changes appear?

Teacher Notes:

A purple color indicates the presence of starch which is made during the process of photosynthesis. Where sunlight was able to reach the leaf, photosynthesis was able to take place, and it is there that starch exists.

Activity: Effect of Light on the Growth of Plants

Objective:

The student will determine how varying amounts of light affect the growth of green plants.

What to do:

Materials needed: Seeds, potting soil, pots, fluorescent lamp, light-tight box.

Grow three plants (beans or peas are a good choice) in potting soil. Place one of the plants in a window where it will receive light throughout the day. Each day turn the pot around so that the plant gets equal light on all sides. Keep another plant under a fluorescent lamp that is on 24 hours a day. Place the third plant in a box that is light-tight. Remove the plant from the box for only five hours daily, and during that time place the plant under the lamp. Give each plant enough water to keep the soil slightly moist.

Compare the growth of the plants.

Teacher Notes:

The plant under the lamp will grow faster because it is receiving the most energy. The one in the window will be the second fastest grower, and the one getting the least energy will grow the slowest.

Activity: Phototropism

Objective:

The students will describe positive phototropism in plants.

What to do:

Exposure of the maximum possible amount of leaf surface to direct sunlight allows the green plant to carry out photosynthesis with the greatest efficiency. Green plants have adapted to this need by the process of phototropism. This enzyme-controlled process causes elongation of shaded stem cells, resulting in a bending of the stem toward a light source.

Place a plant in a sunny window until a noticable bending toward the light occurs. Discuss this with the class. Rotate the plant 180 degrees and opposite bending will occur.

As an alternate demonstration, place bean or corn seedlings in a light tight box with a small hole located on the top, but not directly above the plants. The plants will eventually grow through the hole. Discuss the survival value of this adaptation.

Activity: The Nature of Photosynthesis

Objective:

The student will be able to discuss the general nature of photosynthesis.

Background Information:

Green plants are the earth's major collectors of the energy of the sun, storing this energy in the chemical bonds of carbohydrates, fats and proteins.

The general reaction for photosynthesis is:

$$6CO_2 + 6H_2O \xrightarrow[\text{chlorophyll}]{\text{light energy}} C_6H_{12}O_6 + 6O_2 \uparrow$$

Photosynthesis is actually composed of a complex series of reactions, and cannot really be reduced to a single, simple reaction. The first phase of photosynthesis involves reactions that require chlorophyll and occur only in light. In these reactions water molecules are split and the energy is stored at the cellular level for later use in the fixation of carbon dioxide as glucose, a simple sugar.

An item of great importance is that photosynthesis is the only biological reaction which is dependent upon an outside source of energy: sunlight.

What to do:

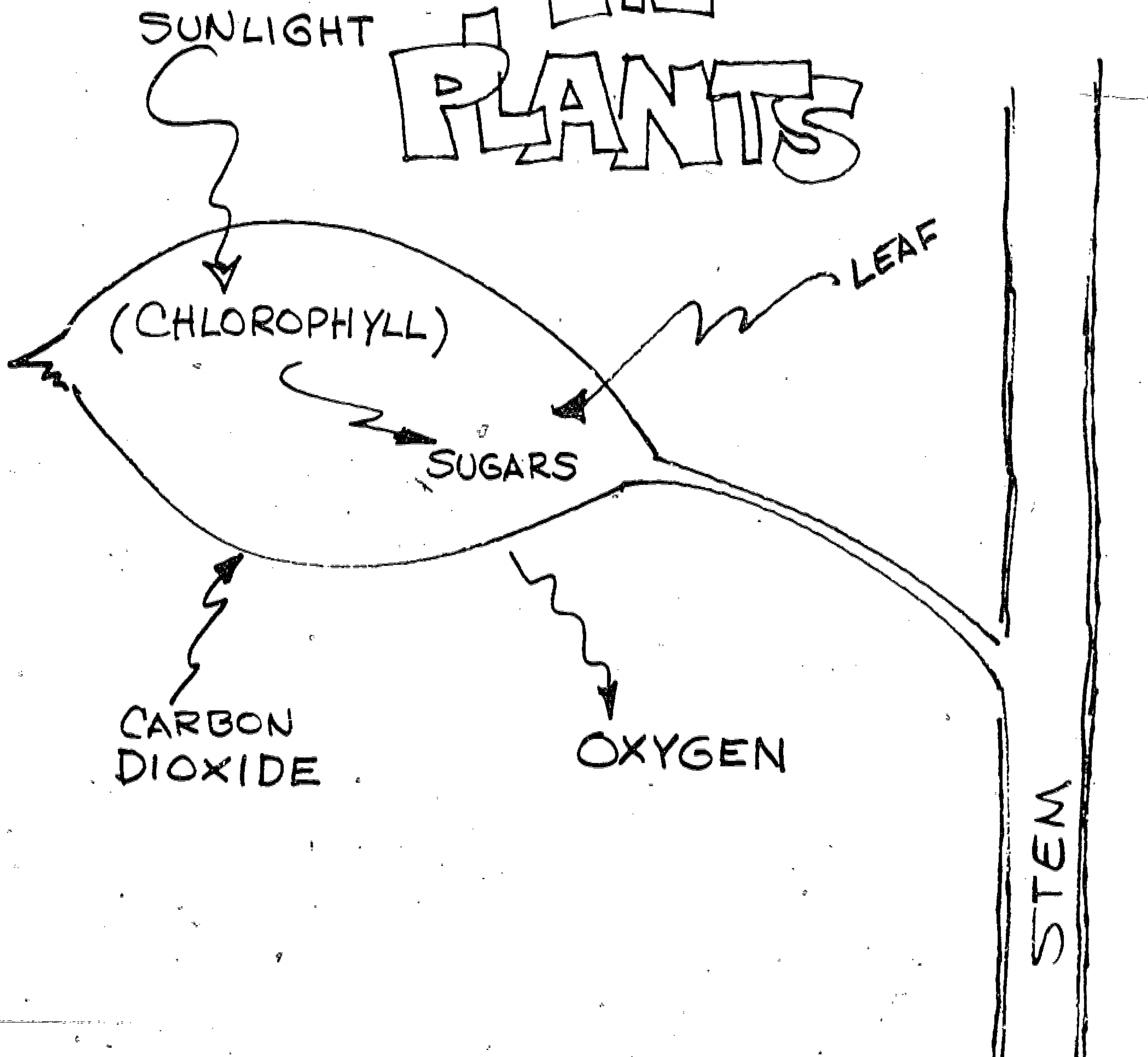
1. Have the class discuss the role of photosynthesis as the energy source of all living things (with a few minor exceptions), because it is the only biological reaction which is dependent upon outside sources of energy.

2. Have the class discuss the dependence of our major fossil fuel energy sources (petroleum, coal, natural gas) upon photosynthesis.

3. Certain wavelengths (colors) of light are used in photosynthesis. Most plants absorb the most energy from violet and blue rays and somewhat less energy from red and orange rays. Devise an experiment using mature bean plants to determine the most efficient light color for photosynthesis.

4. Discuss photosynthesis as the chemical link between the organic and the inorganic worlds.

PHOTOSYNTHESIS IN PLANTS



CARBON DIOXIDE + WATER + ENERGY → SUGARS + OXYGEN

CO_2 + H_2O + SUNLIGHT → $C_6H_{12}O_6 + O_2$

Activity: Chemosynthesis

Objective:

The student will be aware of the nature of chemosynthesis and the potential use of this process in energy production.

Background Information:

Certain bacteria do not depend upon photosynthesis for energy. They possess enzyme systems which can use inorganic chemical reactions to trap energy. They have the ability to organize their own carbohydrates *without using light energy*, and then form all of their proteins, fats and nucleic acids.

What to do:

1. How might we use these bacteria to produce fuels?

2. How might these bacteria survive where green plants cannot?

Activity: Hydrolysis of Starch

Objective:

The student will demonstrate the transformation of insoluble starch to soluble glucose by enzyme activity in living systems.

Background Information:

Starches are complex carbohydrates made up of many glucose units in chains. Each glucose unit in a starch molecule has a molecule of water removed. Starches are insoluble in water, and are stored in many plants such as potatoes, wheat, rice, and corn. Animal starch (glycogen) is produced in the liver and stored there or in muscles. When extra fuel is needed by an organism, the starch is broken down to glucose.

An enzyme in human saliva helps to break down starches in digestion. The soluble glucose produced by this breakdown can then be absorbed for use by the body.

What to do:

1. Give each student an unsalted saltine cracker. Instruct them to chew the cracker for at least 5 minutes *without swallowing*, and to note any change in taste.

2. Questions:

   2.1 What changes in taste occurred as you chewed the cracker? How would you explain this change?

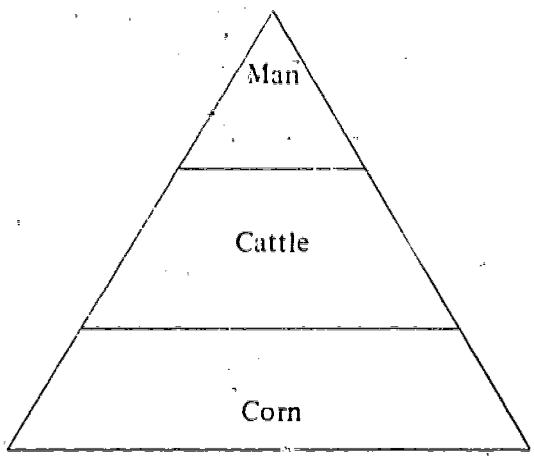
Activity: Food Pyramids

Objective:

The student will explore and explain the transfer of food in a food pyramid.

Background Information:

Green plants, which store the sun's energy in chemical compounds by the process of photosynthesis, form the base of every food pyramid. Primary consumers eat these green plants, and in turn may be eaten by secondary consumers, and so on. However, as the energy is passed from one level of the food pyramid to another, about 85 percent is lost to respriation, excretion, heat and movement. So there is always much more energy at the base of a food pyramid than at the top. A food pyramid might look like this:



If we used 10,000 pounds of corn per year, assuming an 85 percent energy loss in transfer, we could support 150 pounds of cattle, which in turn could support only a 30-pound human. It is obvious that it would be more efficient if the humans ate the corn, shortening the food chain and gaining in efficiency. (10,000 pounds of dry, shelled corn is the average yield from about two acres of Pennsylvania farm land).

What to do:

1. Construct and discuss other food pyramids. (Food chains may interconnect, rather than being straight line).

2. Does the described loss of energy mean that people should not eat meat? How would you like to eat dry, shelled corn 365 days per year? What balance should we use?

3. It is estimated that it requires 90 gallons of petroleum to supply the fuel, fertilizer, and other chemicals to grow one acre of corn in Pennsylvania. How many barrels of oil are needed to sustain one dairy cow (1,400 pound) for one year?

Activity: Food Webs

Objective:

The students will dramatize how energy is distributed through a food web.

What to do:

Using pupils to represent the components, construct models of two or three simple food chains and then convert them into a food web.

Prepare cards lettered with such labels as sun, soil, green plants, mouse, grasshopper, earthworm, snail, frog, shrew, robin, garter snake, rabbit, owl, goldfinch, sparrowhawk, beetle, fungi, bacteria. Prepare enough cards to supply about half the class; let the other half serve as an audience. You will also need a ball of string which can be cut to convenient lengths and used to connect the links in the food chains and web.

Assign the cards to pupils. Have the two pupils representing the sun and green plants hold a length of cord between them. It is important to place these students in the center and allow the remainder of the web to develop around them. Now connect one of the herbivores (plant eaters) to the plants; follow this with carnivore (meat eater) linked to the herbivore. At first the components will depict simple food chains, but as more and more components are added, cross-links between the herbivores and carnivores begin to be evident and the food web concept is developed.

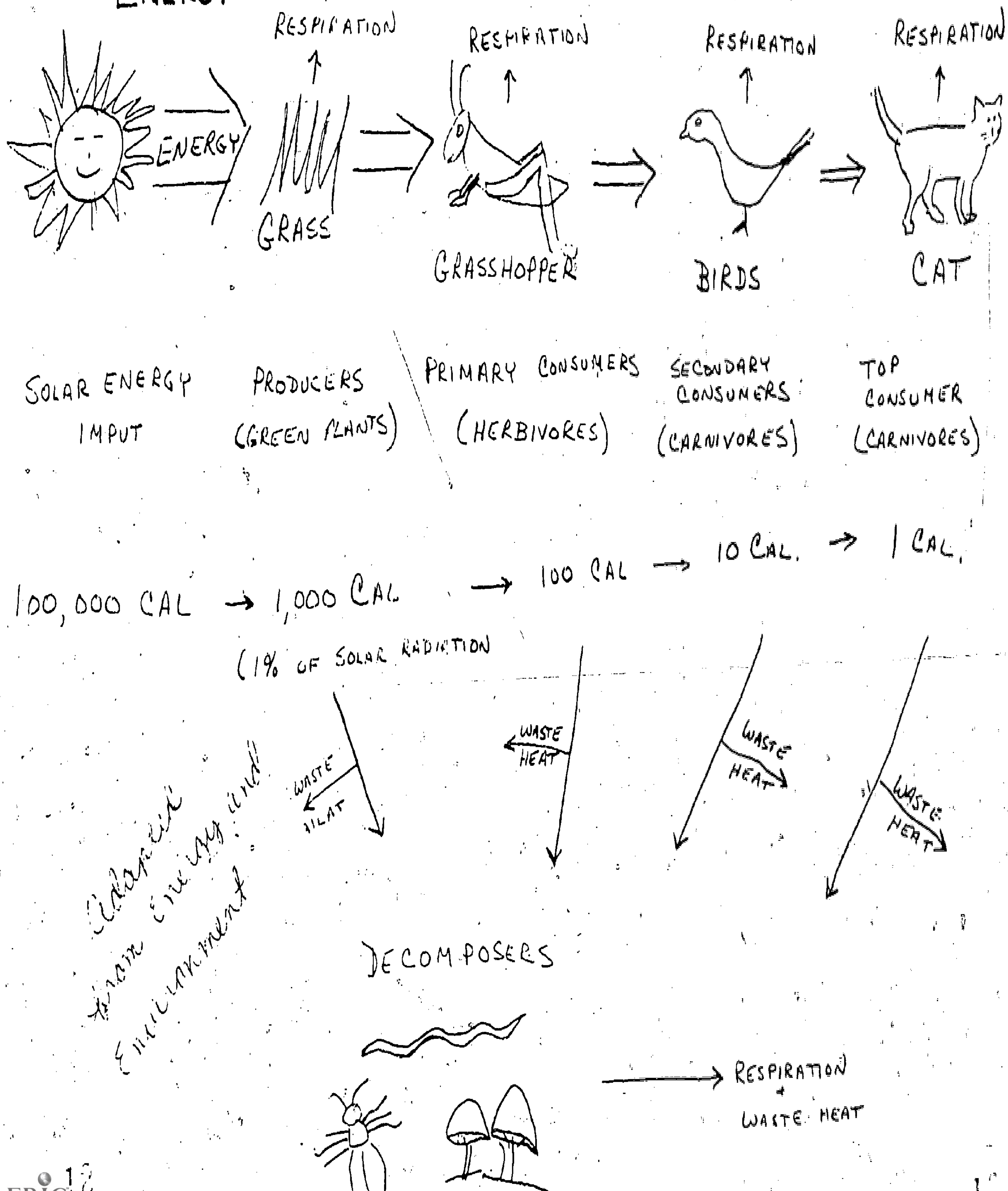
Questions to ask in discussion:

1. Why is the sun necessary for all life?
2. What is the source of food used by animals?
3. In a natural environment, if all the members of a particular species such as grasshoppers were removed from the food web, what would be the effect? (This point can be emphasized by removing the appropriate pupil from the model.)
4. As a part of a food web, how does a human differ from all other organisms?

Teacher Notes:

The sun is necessary because it is the source of energy that plants use to produce food. If a species is removed from the food chain, the animals that feed on that species would have to find another food source, migrate, or starve. Since the elimination of a species means that there is less total energy (food) available in the system, some members of the system will have to be eliminated in some manner. Humans are unique in that they can consciously manipulate the components of a food web. This manipulation often endangers other species. Humans alone have the ability to understand the complex interactions of nature, and also the obligation and responsibility to preserve the balance of the food web.

ENERGY FLOW THROUGH A FOOD CHAIN



Activity: Respiration

Objective:

The student will discuss respiration as the process by which living organisms release the energy stored in organic molecules.

Background Information:

Respiration may be thought of as the reverse of photosynthesis. The overall reaction might be described as:

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2\uparrow + 6H_2O + \text{energy.}$$

Like photosynthesis, respiration is a controlled process, taking place in steps, each of which releases a small amount of needed energy. High temperatures are not involved, for the cell mitochondria, where respiration takes place, could not withstand such temperatures.

What to do:

1. Have your students burn a small amount of plant material in a jar or beaker. Immediately add 10 to 20 ml. of limewater. Cover and shake the container. The milky color of the limewater indicates the presence of carbon dioxide, a product of combustion.

2. Have a student blow his/her breath through a beaker of limewater. Note the milky color indicating the presence of carbon dioxide.

3. Discuss the similarities and differences between combustion and respiration.

Activity: Fermentation

Objective:

The student will describe fermentation as the partial breakdown of glucose by yeast, producing ethanol. He/she will discuss the use of ethanol both as a fuel and as a fuel additive.

Background Information:

In fermentation, the enzyme zymase found in yeast breaks down glucose in the absence of oxygen, producing ethlyl alcohol (ethanol) as a waste product.

$$C_6H_{12}O_6 \longrightarrow 2C_2H_5OH + 2CO_2\uparrow$$

What to do:

1. Place fruit juice (apple or grape) or a 10 percent glucose solution in a 1/2 gallon jug fitted with a one-hole rubber stopper. Add 1/2 teaspoon of granulated dry yeast. Shake well. Put the rubber stopper in place. Attach the rubber or plastic tubing, placing the opposite end of the tubing in a beaker half full of water. Store in a dark, warm place for at least one week, observing daily. Record your observations concerning any activity which takes place.

   a. What evidence of a reaction did you observe?

   b. Describe the smell.

2. When gas no longer bubbles from the rubber tube, remove the tube and decant part of the clear liquid into a clean flask. Have the students describe the difference between the original fruit juice or glucose solution and the present product.

3. Using a Liebig condenser, franctionally distill about 1/6 of the liquid sample into a clean test tube. Have the students describe the properties of the distillate.

4. Ignite a sample of the distillate. Discuss its potential use as a primary fuel (racing cars run on it), or as a fuel additive to gasoline (gasohol), stretching our limited supply of this fuel.

Activity: The Influence of Vegetation on Energy Conservation

Objective:

The student will explain the effect of vegetation on energy consumption.

Background Information:

Trees can have an important effect upon the energy expended to heat or cool buildings. Because their leaves are lost in winter, deciduous trees shade buildings in summer and allow the sunlight through to warm the building in winter. Evergreens may serve as windbreaks.

What to do:

1. Survey the area around the school for vegetation which aids in conserving energy.

2. Prepare a master plan for plantings around the school. (A local nursery or landscape architect may assist in this).

3. During warm, sunny weather, place a thermometer on a grassy area and on the blacktop of the parking lot. Explain the difference in temperatures (this is especially evident shortly after sunset). Why is grass surrounding a building preferable to blacktop?

Activity: Pyrolysis of Fuels from Solid Waste

Objective:

The student will pyrolize solid waste materials and identify the products of this process.

Background Information:

In the 1970's, municipalities spent between three and four billion dollars a year for the collection and disposal of solid wastes. About 80 percent of this waste is combustible, so the potential energy in these wastes is significant, amounting to about 150 million barrels of oil per year. The expected annual organic waste for the year 1980 from all sources is:

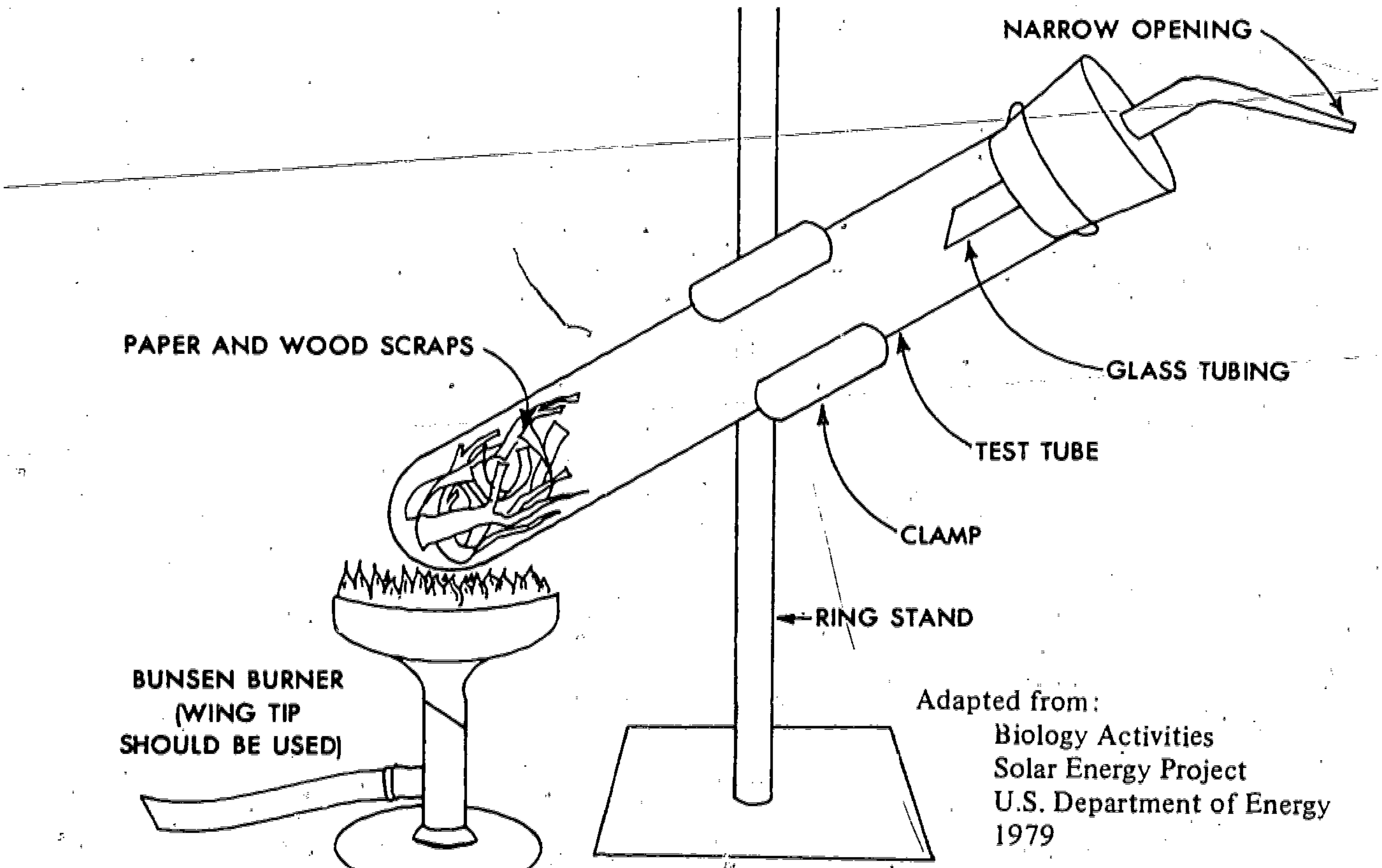
Waste Source	Dry Weight in Millions of metric tons
Urban Refuse	202
Manure	205
Agriculture	355
Industrial	45
Municipal Sewage	13
Other	55

Pyrolysis is the chemical decomposition of organic materials in the absence of oxygen. Organic materials are heated in closed containers, producing a gas, a char (partially burned carbon residue), and a heavy tar-like oil. All three of these products can be used as fuels.

Temperatures required for pyrolysis are low enough that solar devices using lenses or mirrors to concentrate solar energy could be used as the heat sources.

What to do:

1. Set up the apparatus according to the diagram. Place a small quantity of paper scraps and wood chips in the test tube. Note: See next page for diagram.
2. Put on your safety glasses and heat the test tube.
3. Place a burning wood splint at the opening of the glass tubing. Describe what happens.
4. Place the tip of the glass tube into the test tube resting in the beaker of water. Collect several milliliters of tar. Describe the tar. Determine if it burns.
5. What does the solid material look like? Does it burn?
6. Design a simple device which could be used to concentrate sunlight to convert wastes into fuels.



Adapted from:
Biology Activities
Solar Energy Project
U.S. Department of Energy
1979

Activity: Destructive Distillation of Coal

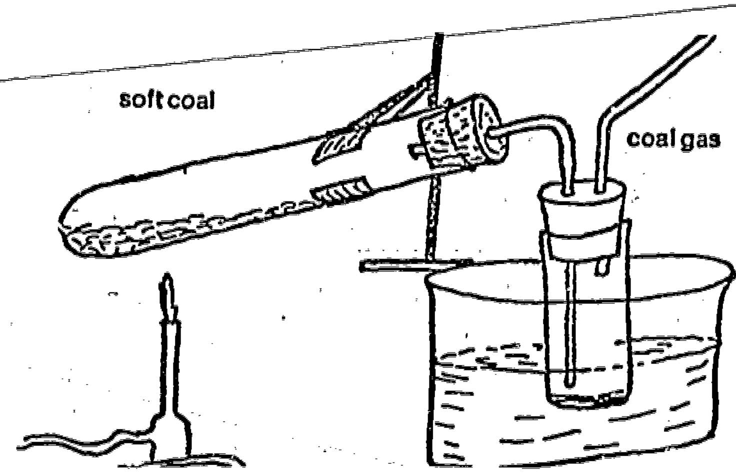
Objective:

The student will test the gases coming off a sample of burning coal.

What to do:

Materials needed: Bunsen burner, glass or plastic container, 2 test tubes, 2 stoppers (one 1-hole and one 2-hole), 2 glass tubes (1-curved 8"; 1-3"), test tube holder, soft coal, water, matches, red litmus paper, lead acetate paper.

This activity involves the destructive distillation of coal. It *must* be done in a well-ventilated part of the classroom or outdoors. Set up the apparatus as shown in the diagram. Fill the distillation tube one-third full with pieces of soft coal and heat the tube. Test the gas which comes off to see it it burns. Then test for hydrogen sulfide by holding moistened lead acetate paper in the gas. (If paper turns black, hydrogen sulfide is present.) Test for ammonia by holding wet red litmus in the gas. (If ammonia is present, the paper will turn blue.) Continue heating the coal until all the gases are driven off. The material remaining is coke.



Burn coke and soft coal. Which produces a better fire? Which material would be better for a fireplace? How does this compare with the pyrolysis of wood?

Activity taken from West Virginia Energy Activities.

Activity: Biomass -- Stored Solar Energy

Objective:

The students will be able to:

1. compute the cord measure of a stack of wood
2. compute the amount of wood required to heat their homes, knowing the amount of coal or oil required for this task
3. compare the cost per million BTU of various types of wood
4. compare the cost per BTU of wood with coal or oil

Background Information:

During their growing season, trees collect solar energy and store it as chemical energy. They accomplish this task by means of the process of photosynthesis, during which the plants capture light energy and use it to change water and carbon dioxide into oxygen and carbohydrates. Plants then use the carbohydrates as a source of energy for their own growth. As plants increase in size, their biomass becomes a potential source of fuel for heating homes.

What to do:

1. Compute a full cord measure of wood:

   a. Compute the volume of wood to be measured, e.g., a pile 7' x 8' x 8' = V = l x w x h = 7' x 8' x 8' = 448 ft^3

b. Since 1 full cord = 4' x 4' x 8', 1 cord = 128 ft^3 Divide the volume of the wood by 128 ft and obtain the cord.

i.e., $\frac{448\ ft^3}{128\ ft^3/cord}$ = 3.5 full cord

c. Determine the volumes and number of full cords for the sample wood listed in table 1.

DETERMINATION OF CORDS

Table 1

Wood Sample	Length Ft	Width Ft	Height Ft	Volume Ft^3	Cord
A	3	5	6		
B	3	6	2		
C	15	12	7		
D	6"	4"	15"		
E	7	9	3		
F	14	12	6		

2. Compute the available heat per pound for various types of wood, and compare the cost/million BTU for each type of wood as given in table 2.

   a. Divide the available heat per cord in BTU's/cord by the weight per full cord in pounds. This will give the available heat per pound in BTU/lb.

   b. Assume a cost per full cord for all types of wood to be $100. Compute the cost/million BTU by dividing the cost per full cord by the available heat per cord in million BTU's per full cord.

3. Assuming that 1 full cord of hardwood is equivalent in heat content to 200 gallons of oil, 1 ton of hard coal, 29,000 ft^3 of natural gas, or 8,400 WKH of electricity, compare the cost of the fuels.

4. Knowing the amount of fuel or electricity required to heat your home for a year, you should compute the amount of wood in full cords that you would need.

5. Questions:

   5.1 Did you note that most species of wood contain essentially the same available energy per pound but vary significantly in density? Which is a better buy if sold at the same price – a cord of dense wood or a cord of less dense wood? Why?

5.2 If one had to buy wood in your area would it be cheaper to heat with wood than with oil, coal, natural gas, or electricity?

5.3 What type of wood is the best buy if sold by cord measure?

5.4 How many cords of wood would you need in order to heat your home?

Teacher Notes:

Wood, a fuel which was common to our forefathers, has once again become a viable source of energy for heating homes. This form of energy is stored solar energy, and this concept should be stressed with students.

It is estimated that the sun falling on land fixes and reduces about 16×10^9 tons of carbon per year. Only 3.5×10^9 tons of coal were mined worldwide in 1970. Apparently, the potential of biofuel is four times the coal resources mined each year. (It should be noted however, that if we burned this much biomass, we would have none left for food, wood, fiber, etc.)

HEATING VALUE OF WOOD

TABLE 2

TYPE OF WOOD	WEIGHT/CORD (AIR DRIED) LBS/CORD	AVAILABLE HEAT/FULL CORD MILLION BTU	AVAILABLE HEAT/LB. BTU	COST/MILLION BTU AT $100/FULL CORD
ASH	3400	20.0		
ASPEN	2160	12.5		
BEECH	3760	21.8		
BIRCH	3680	21.3		
DOUGLAS FIR	2400	18.0		
ELM	2900	17.2		
HICKORY	4240	24.6		
MAPLE	3200	18.6		
RED OAK	3680	21.3		
WHITE OAK	3920	22.7		
PINE (WHITE)	2080	13.3		

Wood, one of the most popular fuels, has many advantages as a fuel. It is storable without a container, portable, safe to handle, and burns relatively cleanly. A cord (4' x 4' x 8') is by definition 128 $ft.^3$ of wood neatly stacked. Actually, a cord contains approximately 80 $ft.^3$ of wood; the remainder of the volume is air. A cord of wood is approximately equal to a ton of coal, or 200 gallons of fuel oil, or 2,900 cubic feet of natural gas or 8,400 KWHof electricity. A face cord or stove cord is typically 16" - 18" x 4' x 8' and is approximately 1/3 of a full cord.

All species of wood contain essentially the same amount of heat/lb. but they differ greatly in densities. When comparing heat contents per coard of wood, you will find differing values in various charts. This is due to the percentage of water contained in the wood more than anything else. The more water the wood contains, the less the heat output, because much of the energy goes into vaporizing this water. The table shown under **Typical Results** lists wood commonly used for fuel and the heat content/cord. Some time could be spent comparing densities per cord or perhaps comparing costs/BTU of one species of wood against another. It is traditional that wood be sold by the cord, and typically the cost per cord is the same for different kinds of wood, yet students should be made aware of the fact that a dense hardwood yields significantly greater heat than softwoods or less dense hardwoods such as willow, poplar etc.

Typical Results **HEATING VALUE OF WOOD**

TABLE 2

TYPE OF WOOD	WEIGHT/CORD (AIR DRIED) LBS/CORD	AVAILABLE HEAT/FULL CORD MILLION BTU	AVAILABLE HEAT/LB. BTU	COST/MILLION BTU AT $100/FULL CORD
ASH	3400	20.0	5814	$5.00
ASPEN	2160	12.5	5787	8.00
BEECH	3760	21.8	5798	4.59
BIRCH	3680	21.3	5788	4.69
DOUGLAS FIR	2400	18.0	7500	5.56
ELM	2900	17.2	5931	5.81
HICKORY	4240	24.6	5801	4.07
MAPLE	3200	18.6	5813	5.38
RED OAK	3680	21.3	5788	4.69
WHITE OAK	3920	22.7	5791	4.40
PINE (WHITE)	2080	13.3	6394	7.52

Adapted from Biology Activities, Solar Energy Project, US Department of Energy, 1979.

It should be noted that the heat can be extracted from the wood by fairly complete combustion. This means sufficient oxygen and high temperatures, conditions one can achieve with dry wood in a fireplace, Franklin stove, or any stove which allows a large amount of air into the stove. However, most of this heat will go up the chimney, and the homeowner will not benefit much from this. As to the heat flow up the chimney, a partial vacuum is created in the house, and the warm air of the house (which has gone up the chimney) is replaced by cold air which is drawn in around windows and doors. This is an important concept that many overlook, and it is the reason why fireplaces and inefficient woodstoves often yield a net heat loss to a house even though it is hot in the room where the device is in operation. The other way to accomplish more complete combustion is to have a stove which is airtight, i.e., it allows very little air to enter the stove. If this type of stove has a secondary combustion chamber, the volatiles released from the wood will recycle inside the stove and will pick up enough energy until they too become oxidized. Some of these new woodstoves with secondary combustion operate at 70-80 percent efficiency, they do not use much air from the house, and they are therefore very effective heaters. It should be noted that efficiency is output/input; so, if the efficiency of a good woodstove is 75 percent and an inefficient stove such as the Franklin stove is 15 percent, (with doors closed) the efficient airtight stive will use only 1/5 the amount of wood that the Franklin stove would use to accomplish the same amount of heating. A simple cost analysis will show that an efficient stove will often pay for itself in one year because of its low fuel consumption. Environmentally, the significance is tremendous also.

Teachers will find that students will readily discuss this information with their parents if they have stoves or fireplaces, or if they live in a house which is cold and uncomfortable.

To tie this in with solar energy, a good discussion could be held on how the densities (and therefore heat content) of the wood depend upon the life of the tree, the length of growing season, etc. which are functions of the amount of solar energy which is captured and stored.

Adapted from:
Solar Energy Project
U.S. Department of Energy
1979

Activity: Biomass

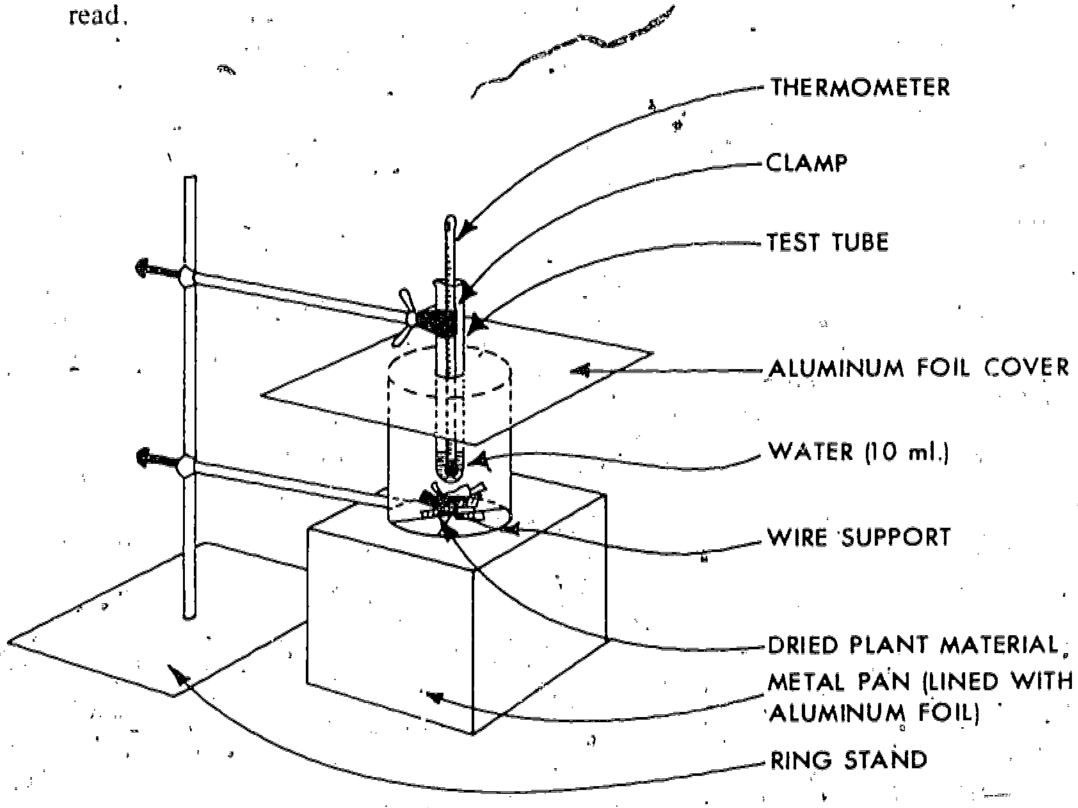
Objective:

The student will measure the heat energy produced by the combustion of a given mass of plant material using a homemade calorimeter.

What to do:

Construct a homemade calorimeter according to the diagram. (Note: diagram on next page) Remove a bean plant from the soil and wash the soil from its roots. Twist the plant into a log shape. Wrap it with paper toweling and allow it to dry for about a

week, or place it in a drying oven. Remove the plant from the paper toweling and determine its mass. Place the dried plant on the wire support. Pour 10 ml of water into a large test tube that is clamped to the ringstand. The bottom of the test tube should be just above the plant material. Place a thermometer in the test tube and record the water temperature. Place aluminum foil over the top of the can surrounding the test tube. Leave enough of an opening around the test tube so that the thermometer can be read.



Place the metal pan lined with aluminum foil beneath the calorimeter. Carefully ignite the plant material. Observe the temperature until all the plant material is burned. Record the highest temperature that the water reached.

Calculate the toal amount of heat energy given off by the plant material using the formula:

Heat in calories = mass of water (grams) x $(T_2 - T_1)$

1 ml of water	=	1 gram
T_2	=	final temperature
T_1	=	initial temperature

1. What was the total amount of heat energy released by your plant?

2. Determine how many watt hours of energy your plant released
   $$\text{(watt hours} = \frac{\text{heat in calories x 1 pound}}{1000}\text{)}$$

3. How much plant material would you have to burn to provide the heat energy equivalent to one gallon of gasoline? (1 gallon of gasoline = 3,615,000 watt hours of available energy).

4. How would you determine the relative efficiency of other plant fuels?

5. Why is the use of this homemade calorimeter able only to yield an approximation of the actual energy released by the plant material?

Teachers Notes:

Perform this experiment under a hood or high draw ventilator.

Wear protective eye glasses.

Exerpted from:
Biology Activities
Solar Energy Project
U.S. Department of Energy
1979

Activity: Pollutants from Energy Production

Objective:

The student will investigate pollutants produced during energy production and some of their effects.

What to do:

1. Obtain ash from a coal furnace or from a sample of coal. Run a small amount of water through the ash. Using an indicator paper, note any changes in pH of the water. How might changes in pH affect plants and animals?

2. Do the same thing for coal (unburned) and for wood ashes.

3. Demonstrate the absorption and assimilation of phosphorous-32 by fish and/or tomato plants. (See: **Radioactivity: Fundamentals and Experiments**, by Hermias and Joecile, Holt, Rinehart and Winston, 1963).

4. Conduct a student experiment on the effects of radiation upon the germination of seeds. (See: Hermias and Joecile, op. cit., pp. 148-151.) Have beans or corn irradiated at a local hospital or buy irradiated seeds from a commercial source. Keep the number of seeds in each sample above 100, varying the radiation dosage. Study rates and percentages of germination.

5. Determine the half-life of a short-lived radioisotope such as barium-137m. (These may be obtained from commercially produced radioisotope generators available from: The Nucleus, P. O. Box R, Oak Ridge, Tennessee 37830).

6. Establish plants in several closed terraria. Study the effects of sulfur dioxide and the oxides of nitrogen upon these plants.

Activity: A Model of the Formation of Coal

Objective:

The student will investigate how fossil fuels are formed.

What to do:

Materials needed: ferns, sand, peat, coal, 10 gallon aquarium, slides or charts of geologic time scale.

Have students examine samples of ferns, peat, and coal. Show the students geologic time charts and describe the physical condition of the earth during the coal forming processes. Then simulate these conditions in the aquarium.

Fill the aquarium with tap water. Add enough peat moss to make a one inch layer. Allow one week to elapse. What is the condition of the water? Include such things as pH, odor, turbidity, decomposition of peat, etc. Have any changes occurred in the peat? Suggest reasons for the changes, or explain why changes did not occur.

Sift moderately fine sand over the peat to a depth of one inch. After the sand settles, add an equal depth of peat. Repeat the process for as long as desired, or until several successive layers have formed. Is coal still being formed today naturally?

This activity from:
Michell Alexander and John Neth
Groveport-Madison High School
Groveport, Ohio

Activity:

Objective:

The students will match various energy equivalents.

Background Information:

A basic unit of energy measurement is the British Thermal Unit, or BTU. One BTU is the amount of heat energy that must be supplied to one pound of water to raise its temperature one degree Fahrenheit.

Energy from all fuels can be converted to BTU's. Approximate conversion rates are as follows:

1-42 gallon barrell of oil ____________ 5.8 million BTU's
1-cubic foot of natural gas ____________ 1031 BTU's
1-kilowatt hour of electricity ____________ 3413 BTU's
1-ton of coal ____________ 25 million BTU's

The word power refers to the amount of energy used or produced in a given amount of time. One important unit of power is the watt. One watt is equal to .00948 BTU per second. One kilowatt is 1000 watts, while one megawatt is 1,000,000 watts.

The kilowatt-hour is the familiar measurement of electricity. A killowatt-hour (KWH) is 1000 watts of power used for one hour.

All electric appliances and light bulbs are rated in watts. For example, a 100 watt light bulb will light for 10 hours with one KWH of electricity. An appliance with a rating of 1000 watts will run for one hour on one KWH of electricity.

In biological processes, the unit of energy is the calorie. One calorie is the heat required to raise the temperature of one gram of water one degree Centigrade. The Calorie (note upper case "C") is called the kilocalorie, and is equal to 1000 calories. One Calorie is about 4 BTU.

What to do:

What equals what?

Try to find a match for each of these. Be careful: they may surprise you!

1. Energy equivalent of 1 barrel of oil.
2. Energy used for the manufacture of 20 aluminum cans using recycled aluminum.
3. 3 months' worth of electricity for a frost-free refrigerator.
4. Total energy use of 800 million Chinese in one year.
5. 350 degrees in your oven.
6. Paper needed to package food in 1 American fast food chain in 1 year.
7. Heat given by the burning of one cord of oak wood.

1. Energy used by the air conditioners of 200 million Americans in one year.
2. 325 degrees in your oven if you use stainless steel, ceramic, or glass dish.
3. Energy equivalent of a man at hard labor for 2 years.
4. Energy used in the manufacture of aluminum can using only virgin aluminum.
5. 174 million pounds of paper.
6. 1 months' worth of electricity for non-frost-free refrigerator.
7. Heat given by the burning of one ton of coal.

Teachers Notes:

Answers:

1-3 A human being requires 341 BTU's of energy for one hour of normal activity.

2-4 If you failed to recycle 2 aluminum cans, you would waste more energy than is used daily by a person in poorer lands.
3-6 A frost-free refrigerator uses much more energy than a manual model.
4-1 The U.S. level of energy consumption is 6 times as high as the world average.
5-2 These types of dishes conduct heat more effectively and thus do not require as hot an oven.
6-5 This amount, 174 million pounds, requires a substantial yield of 315 square miles of forest for one year.
7-7 The heat potential of one cord of wood (80 cubic feet) equals the heat potential of one ton of coal.

Courtesy of:
Park Project on Energy Interpretation
National Recreation and Park Association

Activity: Energy and Lawn Care

Objective:

The students will consider conservation in relation to lawn care.

What to do:

Have the students take a neighborhood poll on lawn care. Ask the following questions:

How much fuel does it take to keep your lawn mowed? (How much per month or per mowing season.)

Do you use any other fuel-consuming garden tools, such as clippers, edgers, mulchers? How much fuel do they consume?

What kind of fertilizers and pest killers do you use on your lawn and garden?

What do you think about unmowed lawns? (Lawns that grow naturally without any care).

Discuss the results of the poll. Is the use of powered garden tools justified? Is a lawn necessary? Is the no mowing idea unacceptable or acceptable?

Activity: Energy in Food Processing

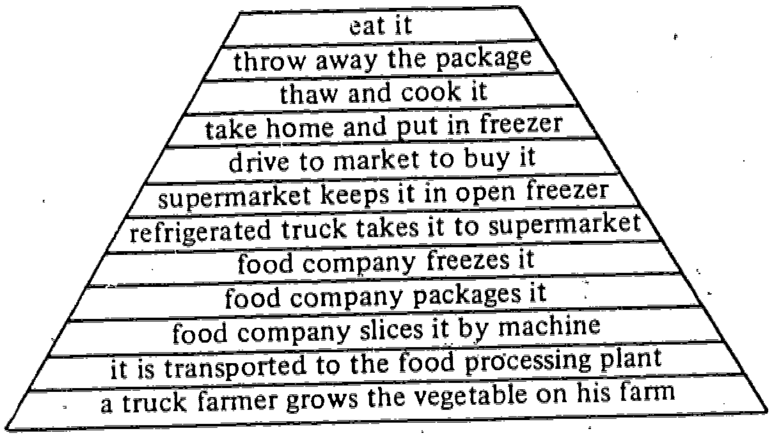
Objective:

The students will identify energy consuming steps in the food system and select ways to save energy.

What to do:
Have the students look at the steps below in the preparation and eating of a frozen vegetable. Have them propose which steps could be eliminated to save energy.

It would be helpful to ask the following questions:

1. Are the car trips less than 1 mile in distance?
2. How else could you get there?
3. How could you cut down on the number of shopping trips?
4. What ways could you recommend to your family to conserve energy when shopping?



Teachers Notes:

The answers will vary. Growing vegetables in your own garden and eating that vegetable raw are the two least energy intensive steps. Have the students construct a food pyramid for pop drinks in cans, TV dinners, ice cream, cereal. Find ways of saving energy for each item. (This activity comes from Energy Conservation in the Home, curriculum guide for Home Economics Teachers produced by ERDA.)

Activity: Compute Your Own Radiation Dosage

Objective:

The student will estimate their annual radiation dosage.

What to do:

Have students complete the following form and compare their radiation dosage with the national average.

COMPUTE YOUR OWN RADIATION DOSE

We live in a radioactive world. Radiation is all about us and is part of our natural environment. By filling out this form, you will get an idea of the amount you are exposed to every year.

	Common Source of Radiation	Your Annual Inventory		Percent
WHERE YOU	Location: Cosmic radiation at sea level Elevation: Add 1 for every 100 feet of elevation . . . . Typical elevations: Pittsburgh 1200; Minneapolis 815; Atlanta 1050; Las Vegas 2000; Denver 5280; St. Louis 455; Salt Lake City 4400; Dallas 435; Dangor 20; Spokane 1890; Chicago 595. (Costal cities are assumed to be zero, or sea level.)	44 —		29.7
LIVE	House construction (based on 3/4 of time indoors) Brick 45 Stone 50 Wood 35 Concrete 45	—		27.0
	Ground: (based on 1/4 of the time outdoors): U.S. Average.	15		10.1
WHAT YOU EAT, DRINK, & BREATHE	Water Food. U.S. average Air	25		16.9
	Weapons test failout	4		2.7
HOW YOU LIVE	X-ray diagnosis Chest x-ray ____ x 9 Gastrointestinal tract x-ray ____ x 210	—		13.5
	Jet airplane travel. Number of 6000-mile flights ____ x 4.	—	0.1%	100
	Television viewing. Number of hours per day ____ x 0.15.	—	0.1%	
	Compare your annual dose to the U.S. Annual Average of 148 mrem.	—		
HOW CLOSE YOU LIVE TO A NUCLEAR PLANT	At site boundary: Annual average number of hours per day ____ x 0.2 One mile away: Annual average number of hours per day ____ x 0.02. Five miles away: Annual average number of hours per day ____ x 0.002 Over 5 miles away. None	— — —	Less Than 0.1%	
	One mrem per year is equal to: Moving to an elevation 100 feet higher. Increasing your diet by 4%. Taking a 4- to 5-day vacation in the Sierra Nevada Mountains.		mrem Total	

Annual radiation doses range from 115 to 215 mrem but might be doubled if medical X-rays are received.

Activity: The Autosaur: A Spoof

Objective:

The students will read and discuss a spoof.

What to do:

Have the students read the following spoof, and then discuss the questions following it.

An Arizona newswriter reports that a memo dated A.D. 3100 states that during the 20th century, the earth was inhabited by huge metallic-looking beasts called autosaurs. These monsters weighed between 1,000 and 4,000 pounds, and could travel at terrific speeds. Although they could be ridden, he relates, they were never completely domesticated by the natives. Apparently thousands of natives lost their lives to them each year.

Around the last few decades of the century, he tells us, the autosaurs mysteriously disappeared. Scientists entertain the the possibility of their having starved to death because of some inexplicable depletion of their food supply. A picture unearthed near Los Angeles supporting this theory shows great lines of these creatures queued up before a feeding station. One of the natives, in an obvious attempt to forestall extinction, is force feeding the leader by means of a hose injected into its "surprisingly small orifice. This effort was evidently unsuccessful." Our writer continues, "While the extinction of any species is to be mourned, it does not appear that the ecological balance of that period was upset by the autosaurs' disappearance. There is even some proof that it improved."

Questions to discuss:

Why does the name autosaur sound scientifically valid?

What characteristics does the writer attribute to the autosaur that reveals its identity?

Which of the author's remarkably logical sounding statements indicates that humans are not always the master of their inventions?

Humor can be instructive as well as entertaining. Do you find an underlying truth in this playful piece of prose? What is it?

Do you think the humor is enhanced by the fact that the story sounds possible and believable?

Which of the following conclusions do you think the author intended?
–We should more carefully protect our endangered species.
–Automobiles kill a great many people.
–The gasoline shortage, in the long run, will be beneficial
to humans and their environment.

Activity: Environmental Impact Statements

Objective:

The students will discuss the rationale, contents, and use of an environmental impact statement.

Background Information:

Before a new power plant, roadway or the like can be built, governmental agencies require that the builder file for approval an environmental impact statement. This statement must include descriptions of what the builder proposes to do, a description of the present environment, the probable environmental impact of the proposed action, mitigating and protective measures, unavoidable adverse effects, alternatives to the proposed action, and other pertinent information. The governmental reviews and hearings concerning this document determine whether or not the proposer is allowed to proceed with the proposed project.

What to do?

Following is the table of contents of an environmental impact statement for a proposed electrical transmission line. Have your class discuss the rationale and possible environmental effects of the items in the table.